FPInnovations

Moisture meters for biomass

Advantage Report Vol.14 No.5 November 2013

Author:

Sylvain Volpé, Forest Feedstocks

fpinnovations.ca

FPInnovations is a not-for-profit world leader that specializes in the creation of scientific solutions in support of the Canadian forest sector's global competitiveness and responds to the priority needs of its industry members and government partners. It is ideally positioned to perform research, innovate, and deliver state-of-the-art solutions for every area of the sector's value chain, from forest operations to consumer and industrial products. FPInnovations' staff numbers more than 525. Its R&D laboratories are located in Québec City, Ottawa, Montréal, Thunder Bay, Edmonton and Vancouver, and it has technology transfer offices across Canada. For more information about FPInnovations, visit: www.fpinnovations.ca.

Follow us on:

301007898: Moisture Meters

Advantage Report – Vol.14 No.5

ACKNOWLEDGEMENTS

This work is possible through integrated research along the entire forest sector value chain at FPInnovations in partnership with Natural Resources Canada. The author would also like to thank the industrial partners that provided biomass samples for measurements, namely JD Irving Limited (Sussex), Coopérative forestière de la Matapédia and Domtar (Windsor).

PUBLICATIONS mail #40008395
ISSN 1493-3381

CONTACT

Sylvain Volpé
Researcher
Forest Feedstocks
514 782-4521
sylvain.volpe@fpinnovations.ca

Table of contents

Keywords

Biomass, moisture content (MC), technology, electric, nuclear, infrared, accuracy, measurement time, sample size, Wile, Humimeter, Troxler, Fujitechnica.

Abstract

One of the challenges to the use of biomass in heat applications is to find a suitable technology to take quick and accurate moisture content (MC) measurements of comminuted forest biomass. In this study, we tested three difference technologies (electric, nuclear and infrared) and five different tools. Of the three technologies tested, electric is the most promising. It is usually inexpensive (<$1000), requires small-sized samples (10 L), is fast to read (<1 minute) and is relatively accurate with more than 70% of measurements within 5% MC of the oven-dried method.

INTRODUCTION

The moisture content (MC) of forest biomass is generally around 50 to 55% when harvested and it can go down to 20% with natural drying. MC is the main factor contributing to the heating value of forest biomass. Therefore, managing the MC of forest biomass and its measurement is critical to the success of bioenergy operations.

MC measurements are often taken manually using labour-intensive methods. The most accurate method of measuring MC of comminuted biomass is to take a sample of about 1000 g, weigh it, and dry it in a forced-air oven at 105°C until the sample stops losing weight according to the EN 14774-2 method, usually within 24 to 48 hours (EN 2009). The difference between the dry and wet (green) weight divided by the wet weight represents the MC (green basis). The main problem with this method is that it takes too long to obtain the MC results and the number of samples is limited due to the cost. Therefore, when forest biomass is delivered to a heating facility, the facility manager isn't able to promptly redirect the product into piles with similar MC. Moisture meters would help determine the MC as soon as a delivery is made. They would also improve efficiency by providing information at any given time on where the driest biomass is located, both in-woods and at the facility.

The challenge is to find a technology that has the potential to take quick and accurate MC measurements of comminuted forest biomass.

TECHNOLOGIES

Electric

- **Technology:** A probe measures the difference between the frequency that it emits and the frequency that returns from the surrounding environment. This difference is used by the probe's computer to calculate the dielectric constant of the material, and hence evaluate its MC. The value of the dielectric constant depends on the basic density of the material, MC, temperature and frequency of the electric current used. At a frequency of 1 kHz, the dielectric constant of dry wood is around 2 and that of pure water is 78 (Nader 1996).
- **Advantages**: Instruments provide fast and accurate measurements. Inexpensive, usually <$1,000.
- **Disadvantages:** Changes in the dielectric constant can only be measured if the water is present in liquid form, so frozen biomass cannot be measured. Also, the dielectric content depends in part on the wood's density and species.

Nuclear

- **Technology:** High speed neutrons are emitted by the radioactive source. Those neutrons are slowed down when they hit the hydrogen atoms present in the biomass. The number of hydrogen atoms is proportional to the MC, so the neutron counts made over a period of time can be related to MC (Nader 1995 and 2002). Nuclear meters are mainly used to measure the density and MC of soil and asphalt in roads during construction.
- **Advantages:** Presence of snow or ice does not affect the device's precision. The device's calibration is independent of species.
- **Disadvantages:** Permits are required (CNSC licence, TDG training, portable nuclear gauge safety training, emergency response procedure) and radiation exposure needs to be monitored at all times with a thermoluminescent dosimeter (TLD). Expensive, usually >$8,000.

Infrared

- **Technology:** A spectrometer measures properties of light over a specific portion of the electromagnetic spectrum. Moisture adsorbs wavelengths specific to infrared. Depending on the MC of the biomass, a different amount of radiation will be reflected back to the spectrometer. The amount of radiation measured can then be converted to MC. Mainly used to measure MC and for quality control tests in food and chemical industries.
- **Advantages:** Meters can be operated with minimal training and have a high degree of precision.
- **Disadvantages:** Some instruments are only suitable for use in controlled conditions (labs) and are not adapted to field conditions. Expensive, usually >$40,000.

ELECTRIC – WILE BIO-MOISTURE

Tool description

- Manufacturer: Farmcomp Oy
- Origin: Tuusula, Finland
- Price: $800

Results

The WILE probe was used to assess the moisture content of harvest residues that were from an in-woods chipping operation and subsequently comminuted with a horizontal grinder (hog fuel) (Figure 1), and logging residue wood chips produced by a drum chipper (Figure 2).

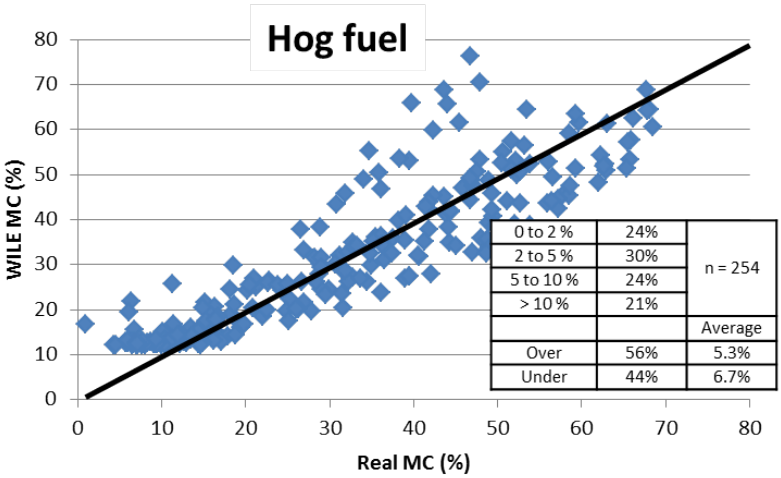


Figure 1. WILE moisture measurements with hog fuel.

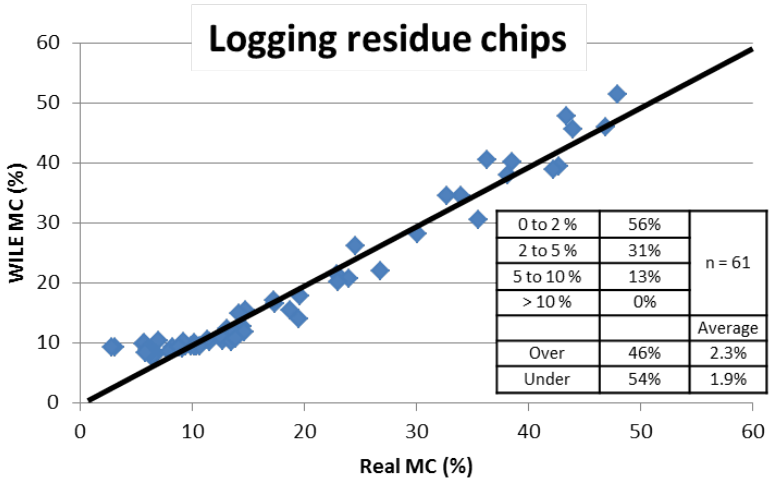


Figure 2. WILE moisture measurements with logging residue chips

Comments

- The tool is easy to handle and operate without any training.
- Measurements can be taken within 1 minute.
- A sample of at least 10 L (4000 g) is required to take a reading.
- The dish probe is well suited for less homogenous material, but readings are sensitive to the physical properties of the various types of biomass.
- Multiple calibration curves need to be established for materials having different physical properties (species, bulk density, particle size distribution) so that a relation between the capacitance reading and the MC is accurate.
- The dish probe gives better results in more homogeneous material as shown with chips from harvest (±3%) compared with bulky material like hog fuel (±6%).
- The number of samples to measure for the average to be within 1% of an oven-determined moisture content is 10 for coarse biomass (hog fuel) and 3 for more homogeneous biomass (chips).

ELECTRIC – WILE BIO-WOOD

Tool description

- Manufacturer: Farmcomp Oy
- Origin: Tuusula, Finland
- Use: only for sawdust and wood pellets
- Price: $800

Results

The WILE Bio-wood was used to assess moisture content of sawdust from a chainsaw (Figures 3 and 4).

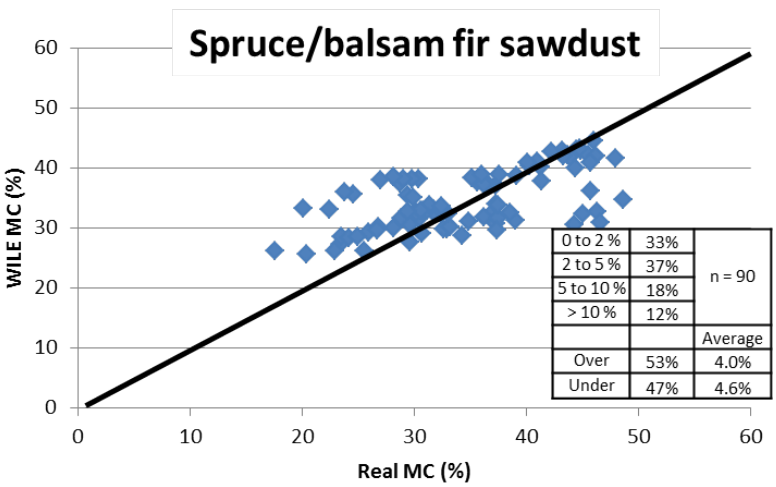


Figure 3. WILE moisture measurements with spruce and balsam fir sawdust.

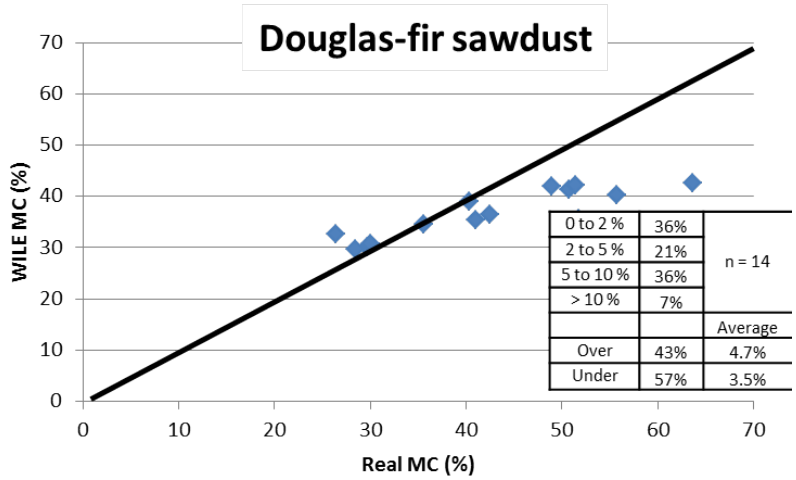


Figure 4. WILE moisture measurements with Douglas-fir sawdust.

Comments

- The tool is easy to handle and operate without any training.
- Measurements can be taken within 1 minute.
- Only a small sample of 0.1 L (50 g) is required to take a reading.
- The measurement principle of the WILE meter is sensitive to physical properties of the various types of biomass.
- Multiple calibration curves need to be created for different species that have considerably different basic densities.
- The WILE sawdust meter gave results within ±4% of real MC for both eastern and western softwood species tested.
- The number of samples to measure for the average to be within 1% of oven-determined moisture content is 6.

ELECTRIC – BM2 HUMIMETER

Tool description

- Manufacturer: Schaller GMBH
- Origin: Austria
- Price: $4,000

Results

The BM2 was used to assess the moisture content of harvest residues that were from an in-woods chipping operation and subsequently comminuted with a horizontal grinder (hog fuel) (Figure 5), and logging residue wood chips produced by a drum chipper (Figure 6).

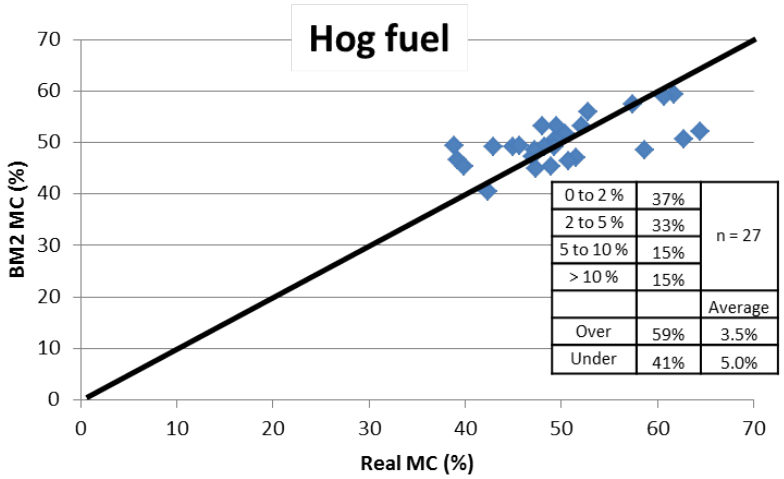


Figure 5. BM2 moisture measurements with hog fuel.

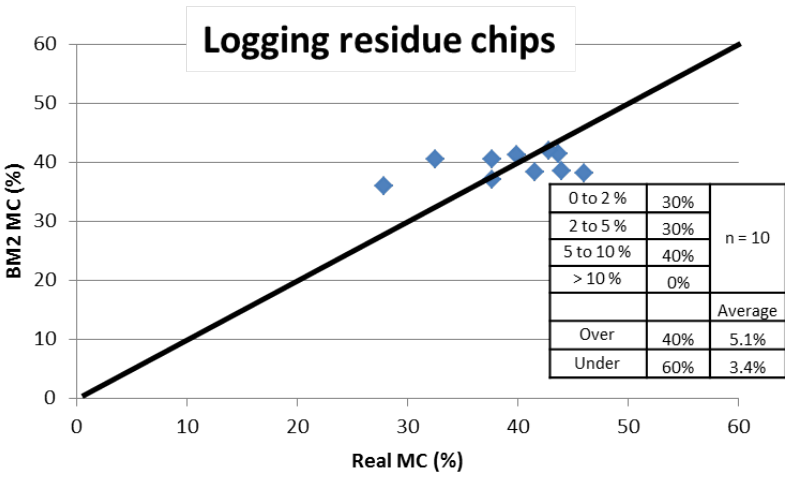


Figure 6. BM2 moisture measurements with logging residue chips.

Comments

- The interface of the moisture gauge is difficult to operate and is not user-friendly.
- Measurements can be taken within 2 minutes.
- A sample size of 13 L (2000 to 4700 g) is required to take a reading.
- Measuring chamber and provided scale (capacity 10 kg) allows users to manage the bulk density of the material being measured.
- Bin structure makes it easy to sample biomass with different physical properties and bulk densities.
- Built-in temperature probe allows for automatic temperature compensation.
- The instrument is expensive compared with similar technologies.
- The BM2 Humimeter had an accuracy of ±4% with the bulky biomass samples measured.
- The number of samples to measure for the average to be within 1% of oven-determined moisture content is 6.

NUCLEAR – TROXLER 4302

Tool description

- Manufacturer: Troxler Labs
- Origin: North Carolina, U.S.
- Price: $10,000

Results

The Troxler nuclear gauge was used to assess harvest residues that were from an in-woods chipping operation and subsequently comminuted with a horizontal grinder (hog fuel) (Figure 7), and logging residues comminuted by a horizontal grinder (Figure 8).

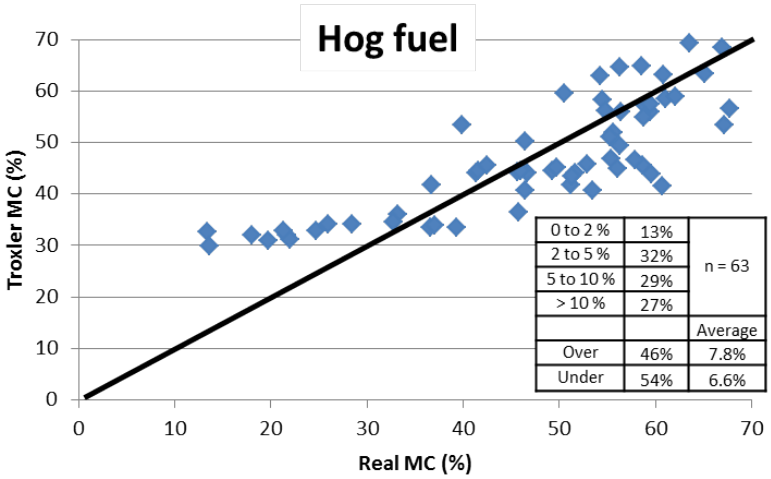


Figure 7. Troxler moisture measurements with hog fuel.

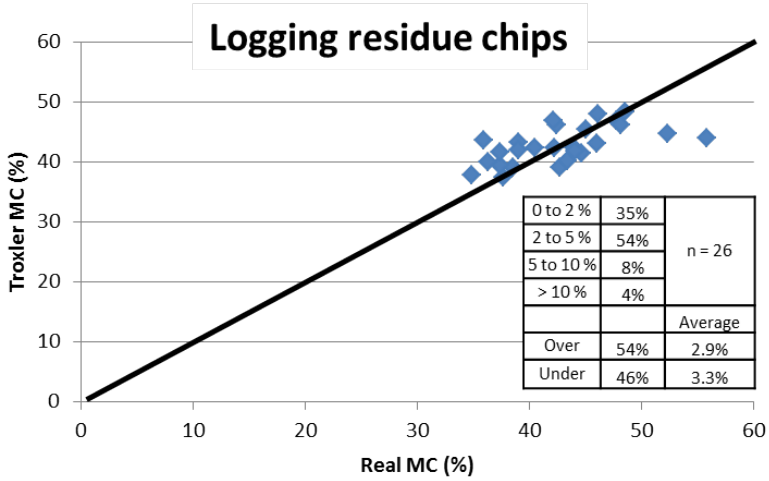


Figure 8. Troxler moisture measurements with logging residues.

Comments

- The interface of the display monitor does not show the direct MC reading. Values measured need to be correlated to oven-dried MC.
- Measurements can be taken within 5 minutes.
- Sample size of at least 60 L (24 kg) is required to take a reading.
- Nuclear gauges require a lot of permissions and safety procedures (CNSC licence, TDG training, portable nuclear gauge safety training, emergency response procedure).
- Radiation exposure needs to be monitored at all times with a thermoluminescent dosimeter (TLD).
- Probe makes it easy to sample biomass with different physical properties (i.e., frozen biomass and bulk densities).
- The Troxler gauge gave better results in more homogeneous material as shown with harvest residues (±3%) compared with bulky material like hog fuel before grinding (±7%).
- The number of samples to measure for the average to be within 1% of oven-dried determined moisture content is 13 for coarse biomass (hog fuel) and 4 for more homogeneous biomass chips.

INFRARED – FUJITECHNICA IM-3SCV MODEL 1900

Tool description

- Manufacturer: Fujiwork Co., Ltd.
- Origin: Japan
- Price: $40,000

Results

The Fujitechnica spectrometer was used to assess the moisture content of harvest residues that were from an in-woods chipping operation and subsequently comminuted with a horizontal grinder (hog fuel) (Figure 9), and logging residue wood chips produced by a drum chipper (Figure 10).

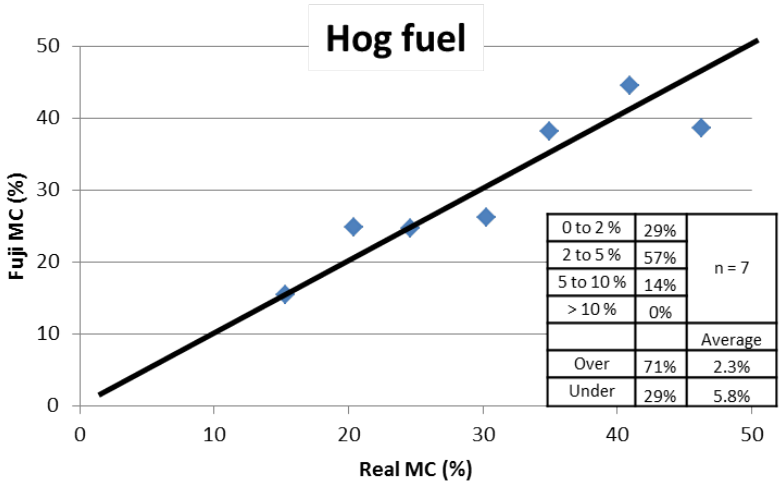
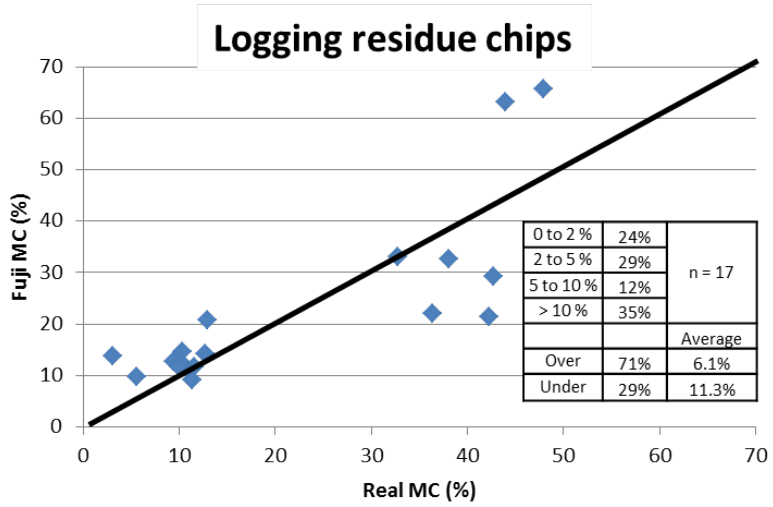


Figure 9. Infrared moisture measurements with hog fuel.



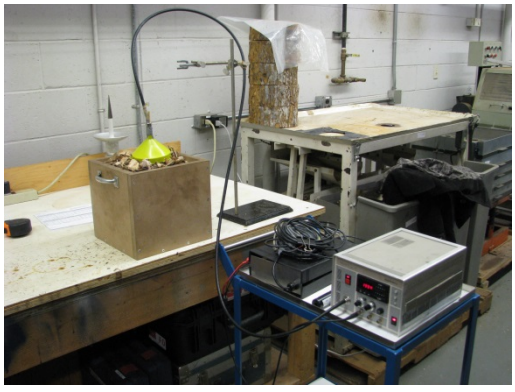


Figure 10. Infrared moisture measurements with logging residues.

Comments

- The interface of the display monitor does not show direct MC readings. Values measured need to be correlated to oven-dried MC.
- Measurements can be taken within 1 minute.
- Small sample size (<1 L) required as measurements are taken on specific surface areas.
- Surface measurement makes it easy to sample biomass with different physical properties.
- The instrument is designed to take measurements in controlled conditions (labs) and cannot be used in field conditions.
- The Fujitechnica spectrometer, on average, is accurate within ±8% for harvest residues compared with ±3% for hog fuel.
- The number of samples to measure for the average MC to be within 1% of the oven-determined MC is 4 for hog fuel and 15 for biomass chips.

RECOMMENDATIONS

- Of the three technologies tested, electric is the most promising. It is usually low priced (<$1000), requires small samples (10 L), is fast to read (<1 minute) and is relatively accurate with more than 70% of measurements within 5% of the oven-determined MC. The main disadvantage is that it cannot be used on frozen biomass.
- The use of nuclear technologies is too restricted (required permits, safety training, etc.) and equipment is expensive (>$10 000). Overall accuracy would not justify the capital investment in money and time.
- Infrared technologies have the reputation of being very accurate, but their high cost (>$40,000) and restriction to lab use make it an unsuitable tool for biomass moisture measurement.
- The main recommendations when choosing a moisture meter for biomass are:
    - Field usability: Light, weatherproof, user-friendly
    - Accuracy: Have 70% of measurements within 5% of oven-determined MC. This usually means that the average deviation will be about 4% and about 6 samples should be taken in order to have an average MC within 1% of oven-determined MC.
    - Measurement time: Sample preparation and reading time <1 minute
    - Sample size: <10 L (about 4 kg depending on MC and bulk density)

REFERENCES

EN. 2009. EN 14774-2:2009 Solid biofuels – Determination of moisture content – Oven dry method – Part 2: Total moisture – Simplified method. European Committee for Standardization published standard.

Nader, J. 1995. Measurement of chip MC with the Troxler 3241-C portable nuclear gauge. Forest Engineering Research Institute of Canada (FERIC), Pointe-Claire, QC. Field Note General-45. 2 p.

Nader, J. 1996. Measurement of the MC of wood chips using Troxler's CP moisture system. Forest Engineering Research Institute of Canada (FERIC), Pointe-Claire, QC. Field Note General-49. 2 p.

Nader, J. 2002. Measuring the MC of wood chips with Troxler's DMG 4302 nuclear probe. Forest Engineering Research Institute of Canada (FERIC), Pointe-Claire, QC. Advantage Vol. 3 No. 26. 2 p.

FPInnovations®

Head Office

Pointe-Claire

570 Saint-Jean Blvd

Pointe-Claire, QC

Canada H9R 3J9

T 514 630-4100

Vancouver

2665 East Mall

Vancouver, BC

Canada V6T 1Z4

T 604 224-3221

Québec

319 Franquet

Québec, QC

Canada G1P 4R4

T 418 659-2647